minently charge of the initiation and diffusion of technical education in this country, have thus far most liberally furnished the means required, and have thus earned the gratitude of the country; but as the development of the scheme progresses an even and commensurate flow of further contributions is required, which, being voted in many cases but annually, at once demonstrates the somewhat precarious conditions on which this important enterprise is dependent.

It is to be hoped that a more general recognition of the absolute need of an education of a higher scientific character both for masters and men will before long have its proper effect; and that the ways and means will be forthcoming to carry out a work which promises so well, and that the Central Institution may then stand a fair comparison with numerous institutions of a similar kind in other countries which have already helped in so marked a degree to advance the industries of those countries.

The mistaken notion is still too prevalent that technical education has to confine itself to the theoretical considerations of known technical processes, and that a more extended acquisition of scientific knowledge is not required. It is obvious that a pupil educated on these lines may find by the time he is able to enter on his practical career that the processes with which he has been made acquainted have in the meanwhile become obsolete, and unless his education has been sufficiently comprehensive to enable him to strike out new lines for himself he will be ill fitted to compete with those who have been educated on a wider basis.

Essential as it is to impart to the future manager scientific knowledge, it is above all necessary to train him by practical work and research in the laboratory how to investigate a subject which may present itself in his daily occupation, whether it be some unexpected development in a new direction, or whether it be some new difficulty which confronts him in carrying out the processes under his direction.

It is self-evident that such knowledge and such practical experience in carrying out investigations is not to be attained by merely attending one or two courses in the lecture-room or in the laboratory. Those who mean to effectually qualify themselves for such functions can only accomplish this object by devoting years of patient and intelligent work under the guidance of the professor in properly appointed laboratories.

THE INSTITUTION OF NAVAL ARCHITECTS

THE spring meetings of the Institution of Naval Architects this year were, to a considerable extent, adversely affected by the recent death of Mr. William Denny, of Dumbarton, the eminent shipbuilder, who was for many years one of the most active members of the Council, and who was foremost amongst the mercantile shipbuilders of this country in the application of scientific methods to naval architecture. Mr. Denny, as is well known, set up at Dumbarton a large experimental tank similar to that contrived by the Admiralty at Torquay for the late Mr. W. Froude, F.R.S., and in which most of his famous experiments on the resistances of the hulls of ships were carried out. It is not often that manufacturers can be induced to spare time and money for the purposes of scientific investigation, even when such investigation is directly conducive to the success of their business. But Mr. Denny was an exceptional man. He firmly believed in the mercantile value of exact scientific knowledge, and he possessed the courage and the ability to act up to his beliefs. It is satisfactory to know that he considered himself fully repaid for the risks he ran, in the results which he attained.

The opening address of the President dealt, as might have been expected in this Jubilee year, with the remarkable progress in steam navigation achieved during the fifty years of Her Majesty's reign; a progress which must certainly be acknowledged to be extraordinary when we remember that, at the commencement of the reign, the late Dr. Lardner publicly offered to eat the first steamship which should cross the Atlantic, whereas nowadays we have vessels which make the passage in a few hours over six days, and a fuel consumption at sea of 1¼ pounds of coal per indicated horse-power per hour is not uncommon. The speaker alluded to the various improvements, such as the use of steel in the construction of both hulls, engines, and boilers, the adoption of high-pressure steam and triple compounding, &c., which have principally contributed to the remarkable results attained.

The first paper read was by the late Director of Naval Construction at the Admiralty, Sir Nathaniel Barnaby, and dealt with the important subject of the connexion between the Royal Navy and the merchant service. This paper was rather political than technical in its character. The author's main object was to support the Admiralty in their recently announced policy of so organising the mercantile marine as to increase the power of national defence. He pointed out that a fast and properly constructed mail steamer may be as efficient a factor in naval war as an ordinary cruiser costing a quarter of a million sterling; and that there are even certain services which the mail-steamer, by reason of her greater size and travelling power, can perform better than the cruiser. On the other hand, the great mass of our mercantile marine is now relatively weaker than it has ever been before against the attacks of an enemy; for in the wars of the last century such ships as the armed East Indiamen possessed a well-recognised fighting value, but nowadays warships are so specialised that the majority of merchant vessels possess no powers of resistance whatever. Sir Nathaniel Barnaby also called attention to the fact that the State makes provision annually for a reserve of seamen, who are drilled periodically and paid by it, and who are liable to be called out to serve in case of war; and he then proceeded to show how, by good organisation, the superior merchant-ships, if manned mainly by naval reserve men, could in case of war be immediately available for service in whatever part of the world they might chance to find themselves. At the present moment the Royal and mercantile navies are under the control of two different Departments of State, and by some strange perversity the First Lord of the Admiralty is almost the only great political officer of State whose name is not to be found on the long list of members of the Board of Trade. As a natural consequence there is no community of action between the two Departments, and no organisation at present exists by which the services of the better class of fast merchant steamers could be rendered instantly available in case of war. The author's cure for this condition of affairs is the creation of a Secretaryship of State for the Navy, so that the interests of the merchant shipping and the Royal Navy might be united, and a truly national marine formed. There is no doubt but that Sir Nathaniel Barnaby in reading this paper has called attention to a very serious set of evils, which may all be remedied by a little organisation and by co-operation between two of the Departments of State. Even if the Board of Trade did not see its way to help in the work, what is to prevent the Post Office authorities from backing up the Admiralty by declaring that they would in future give the preference for mail-carrying purposes to steamers which fulfilled the Admiralty requirements of speed, subdivision, and structural strength, and what is to prevent the Admiralty from assisting the Post Office to obtain a cheap and efficient mail service by granting moderate retaining fees or subsidies to such steamers, provided they were always manned with a due proportion of naval reserve men and trained officers, and provided also that in consideration of the yearly subsidy their services were to be always at the disposal of the State in case of war at a fixed rental to be arranged beforehand. A beginning has undoubtedly been accomplished in the arrangements recently concluded between the Cunard and the White Star Lines on the one hand, and the Admiralty and the Post Office on the other, but much yet remains to be done, and we earnestly trust that Sir Nathaniel Barnaby's paper may be brought under the serious notice of those upon whom will devolve in time of war the care of our mercantile navy and the protection of our food supplies.

M. L. de Bussy, the Inspecteur-Général du Génie Maritime in the French Ministry of Marine, read a short paper on the results of a series of trials carried out on a torpedo boat at progressive speeds, in which he called attention to the fact that there is a diminution in the resistance of the hull after a certain speed has been passed. This fact was, however, already well known to members of the Institution, the peculiar sinuosities, or humps, as they are called, on the speed and power curves of vessels tried at progressive speeds having been often discussed at previous meetings. When all the causes of resistance to propulsion are separately analysed and expressed by correct formulæ, the causes of these successive maxima and minima of resistance will no doubt be clearly intelligible.

Mr. J. H. Biles, the scientific adviser of the firm of Messrs. J. and G. Thomson, of Glasgow, read an interesting paper on the twin-screw torpedo boats, *Wiborg* and *El Destructor*, constructed by his firm for two foreign Governments. The author first gave full particulars of the dimensions of the boats and engines, and their performances. These vessels were considerably larger than the generality of first-class torpedo boats, the *Wiborg* being 142 feet 6 inches, and the *Destructor* 192 feet 6 inches in length. They are both minutely subdivided, the former being provided with 23 and the latter with 39 water-tight compartments, the object being, of course, to enable them to keep afloat as long as possible when exposed to the fire of machine guns. The paper is interesting as showing the most recent tendency in torpedo-boat design. Recent experience in this country and in France undoubtedly points to the conclusion that the older type of first-class boats, though useful enough for harbour defence, are of little or no avail for service at sea. Whether the latest types described by Mr. Biles will fulfil reasonable expectations in this direction is a question which can only be solved *ambulando*. It may be noticed as a curious instance of the skill of modern marine engineers in evolving enormous powers out of engines of limited size, that the *Destructor*, whose load displacement is only 480 tons, has developed over 3800 horse-power, and has made the run of 495 knots from Falmouth to Muros in twenty-four hours, which corresponds to a mean speed of 20·625 knots.

Mr. Dixon Kemp, a well-known authority on yachting matters, read an interesting historical paper entitled "Fifty Years of Yacht-Building," in which he traced out the gradual evolution of the English and American types of racing yachts from the commencement of the present reign down to the most recent times. The author brings out very clearly the causes which have led to the adoption of the relatively narrow and heavily lead-ballasted boats which have hitherto found favour on this side of the Atlantic, and the broad, shallow, centre-board yachts peculiar to the Americans. In view of the recent triumphs of the American type, as represented by the *Puritan* and *Mayflower*, an alteration has been considered desirable in the old tonnage rule which taxed the beam so severely. The Committee of the Yacht-Racing Association appointed to report on the subject have recommended the following rule:—

$$\text{Rating} = \frac{\text{Length of loadline} \times \text{sail area}}{6000}$$

The first outcome of the new rule is the Clyde-built yacht *Thistle*, the principal proportions of which contrast strongly with those of the now famous *Galatea*, as will be readily seen from the following figures:—

	Galatea.	*Thistle.*
Length of loadline	87·0 feet	85·0 feet
Beam extreme	15·0 ,,	20·3 ,,
Draught of water	13·5 ,,	14·1 ,,

It should be mentioned that in the case of the *Thistle* the depth of the hold is measured to the bottom of the keel, which is a hollow box intended to hold the lead ballast. The contests, which will doubless take place during the coming season, between the *Thistle* and some of the powerful American centre-board yachts, will be watched with great interest by yachtsmen. Whether a contest between a keel-yacht and one fitted with the centre-board is a satisfactory trial of merit is at least open to question. In this connexion it may be mentioned that a yacht like the *Mayflower* when sailing off the wind can effect a reduction of 10 per cent. in her immersed surface by housing the centre-board, an advantage which is manifest, especially in the case of light winds and slow speeds.

A subject of great importance with regard to iron and steel ships is the protection of their bottoms from corrosion. Mr. V. B. Lewes contributed a valuable paper on the nature and genesis of rust, and on the protection of plates from its effects. It seems now to be generally admitted that the corrosion which distinguished some of the earlier steel-built ships was due to the presence on the plates of mill-scale or black magnetic oxide of iron, which forms, with the metal of the plate, a powerful galvanic couple, and gives rise, in the presence of sea-water, to very rapid pitting or local corrosion. The action is, in fact, similar at the outset to that which takes place between metallic lead and its peroxide in the well-known Planté secondary batteries. At the present time, steel plates are always carefully freed from this magnetic oxide before being worked into the hulls of ships—a practice which has been attended with the best results. Mr. Lewes believes that the protective compositions of the future will be made by dissolving a good sound gum, not easily perished by sea-water, in a volatile solvent, care being taken that neither gum nor solvent give rise to any organic acids. Body will be given to this varnish by finely-divided metallic zinc, which can now be obtained in so fine a powder that it can be used as a pigment. When, in time, the varnish perishes, as it must do from the action of sea-water under pressure, the zinc will set up galvanic action with the hull-plates; but, being the more electro-positive of the two metals, it will corrode, and will thus protect the iron or steel plates. This paper does not deal with the much-vexed subject of anti-fouling compositions—a much larger subject, which the author reserves for a separate memoir.

Sir Nathaniel Barnaby read a second paper on the subject of fuel-supply in ships of war, which, together with a paper by Mr. Biles, on the comparative effects of belted and internal protection upon the other elements of design of a cruiser, apparently provoked more interest and discussion than any other communication made to the Institution this year. The ships to which Sir Nathaniel Barnaby alluded were the *Impérieuse* and *Warspite*, belted cruisers, for the design of which he was himself chiefly responsible. These vessels have lately been the subject of much adverse comment both in and out of Parliament. As originally designed, the armoured belt was intended to reach from a height of 3 feet 3 inches above the water-line to a depth of 4 feet 9 inches below it. The supply of coal on which this calculation was based was 400 tons, but bunker space was allowed for an additional supply of 500 tons. During construction various additions were made to the weights of the boilers and the armament, which in their turn involved an increase in the weight of hull, and the net result was that the total weight of each ship was increased by 415 tons. Moreover, the present Board of Admiralty have decided that war-ships are in future to coal up to their full stowage capacity; that is to say, in the case of the *Impérieuse* and *Warspite* 500 tons more fuel are to be carried than the designer allowed for. As a natural consequence, the addition of 915 tons to the total weight of each vessel has immersed these ships so deeply that the height of the armoured belt above water has been reduced from 3 feet 3 inches to a little under 1 foot, and there are not wanting those who declare that this circumstance greatly injures, if it does not totally destroy, their fighting efficacy. Sir Nathaniel Barnaby very successfully proved that the responsibility for the additions to the weights of the hull and machinery belongs to the then Board of Admiralty, and not to himself. He also demonstrated that the addition of the extra 500 tons of coal was a case of deliberate reversal of the policy of one Board by its successor, but, judging from the tone of the discussion, he failed to convince his audience that the original policy of calculating the immersion of the belt on a fuel-supply of 400 tons was a wise one.

Mr. Biles's paper, above referred to, on the armour question, was an interesting and useful attempt to solve a difficult problem. He commenced by taking, as the basis of a definite comparison, the latest type of British belted cruiser, viz. the *Aurora*, of 5000 tons displacement. This vessel has a belt 5 feet 6 inches wide, of which 1 foot 6 inches is above the load-line; the thickness of the belt is 10 inches, and its top edges are united by an armoured deck 2 inches thick, under which are placed all the vitals of the vessel. With this he compares a type of cruiser without any side armour, but protected by means of a plated deck, the sides of which curve down so as to join the bottom some feet below the water-line, the curved or sloping portions of the deck being covered with armour of the same horizontal thickness as the *Aurora's* belt. In making the comparison he assumes—

(1) That the length and draft of the proposed vessel are to be the same as in the case of the *Aurora*.

(2) That the displacements are to be the same in each case.

(3) That the costs are to be the same.

Mr. Biles claims that in design No. 1 the internally protected vessel would weigh less than the belted cruiser by about 210 tons; that it would cost nearly 40,000*l*. less; and that the designer would have the option, on the smaller displacement, of either increasing the thickness of the flat portion of the armoured deck by 40 per cent. amidships, or of adding about six-tenths of a knot to the speed, or finally of adding one 9·2-inch gun and two 6-inch guns to the armament.

In the case of design No. 2, where the displacements of the two types are equal, it is estimated that either a knot and a half might be added to the speed, or else that the thickness of the whole of the deck-plating might be increased by 44 per cent.

Lastly, on the assumption that the cost of the vessels is the same, Mr. Biles claims for the internally protected vessel the following important advantages: viz. 20 per cent. greater thickness of protection on the slope of the deck, 50 per cent. more on the flat, two more guns of the heaviest calibre, 20 per cent. more coal, and one knot additional speed. Mr. Biles very pertinently asks the question, Is the adoption of the belt worth the extra money paid for it with its accompanying sacrifices? or, If the money is to be spent, is the belt worth the sacrifice of speed, protection, and armament, which is entailed in its adoption?

The papers on marine engineering were not quite so interesting as some which have been read at recent meetings of the Institution. There were three on the subject of screw propellers, by Prof. Cotterill, F.R.S., Mr. Calvert, and Mr. Linnington of the Admiralty, and one on the machinery of small boats, by Mr. Spyer, also of the Admiralty. In addition to the foregoing there were two papers on stability, a subject which has been perhaps lately somewhat overdone; and an important contribution by Mr. Archibald Denny on the practical application of stability calculations in relation to the stowage of steamships. Mr. Jenkins, the newly-appointed Professor of Naval Architecture at Glasgow University, prepared a paper on the subject of the shifting of cargoes.

STROMEYER'S STRAIN-INDICATOR

THIS is a very useful and ingenious apparatus for measuring the extension or compression produced on any material by tensile or compressive forces. Such deformations having been observed, the corresponding variation in the stresses to which the material has been subjected may at once be inferred by the ordinary law of elasticity connecting strains and stresses in solid bodies. The instrument affords one of the many examples of the valuable results obtainable by the simplest possible mechanical means—results which before the construction of the strain-indicator were considered altogether unattainable.

The instrument is shown in the woodcut, and consists of two flat plates, T, B, about 1½ inch wide and of any convenient length, pressed together by means of two springs, S, S, in such a manner that one plate projects at one end and the other at the other end. The plates are free to slide over each other at their ends opposite A. Fixed centre-points, C, C, are screwed one into each end of each plate, and a graduated dial, D, is attached to the upper one of the two plates T. Two of these instruments are held together by a pair of clamps, K, K, fixed just over the centre-points, which, when screwed tight, press the centres against both sides of the test-pieces; for safety against slipping, a few taps of a hammer embed them more firmly. The figure shows a round bolt about to be operated upon by tensile force, the screwed ends forming attachments to the grips of the testing-machine. Then, when everything is ready, a pair of very fine hardened steel wire rolling pins, P, P, to which light pointers have been attached, are inserted between the plates. These rolling pins, when in position, should be in the centres of the dials. On applying the load to the test-piece, elongation takes place; the centre-points move slightly away from each other, carrying the plates with them, which, as they move in opposite directions, and as they are held